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Art. IX.—*Historic Fossil Cycads*; by G. R. Wieland.

The silicified cycadeoidean trunks, *Cycadeoidea etrusca* Capellini et Solms, conserved in the Aldrovandi Museum at Bologna, and *C. Reichenbachiana* (Goeppert) Solms of the Zwinger Museum at Dresden, must certainly be reckoned amongst the most distinctly famous of all fossil plants.* For both these fossils are of the greatest structural interest; and while the former has a fair claim to be regarded as the most anciently collected of all geological specimens, the latter has the double distinction of having been longer conserved in museums than any other cycad trunk, and of long having been the largest known specimen of its kind. In fact it still remains in the foremost rank among the very largest of all silicified cycads, since it is only a segment of a single trunk; whereas our American specimens of a greater size are either *complete* columnar trunks or else great branching trunks. Furthermore, while *Cycadeoidea etrusca* has the distinction of having yielded the first clue to the approximate position of staminate fructification in the Cycadeoideæ through Count Solms' discovery of its pollen grains, the great Zwinger Museum trunk is in no small measure notorious as an unstudied specimen which has urgently demanded study for quite a hundred years,—that is, ever since

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* The original description of *Cycadeoidea etrusca* is given in the contribution of Capellini and Solms, I tronchi di Bennettitee dei Musei Italiani, Notizie storiche, geologiche, botaniche, Mem. d. R. Accad. d. Sc. dell' Ist. di Bologna, Ser. IV, vol. x, 1890.

The chief data relating to the history of *Cycadeoidea Reichenbachiana* have been brought together by Professor Ward under the caption "A Famous Fossil Cycad," in this Journal, vol. xviii, July, 1904. Direct references to these and other papers mentioned, or facts cited here, may be found in the writer's work, "American Fossil Cycads," Publication No. 34 of the Carnegie Institution of Washington. Washington, August, 1906.

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the development of methods for the study of rocks in thin sections. It is hence of some interest to record that, following my studies of American Cycads, I have recently had the opportunity of seeing both of these famous fossil plants, as well as the equally interesting *Williamsonia* casts of the James Yates series of the *Jardin des Plantes* and other collections, and also the unique Triassic form *Anomozamites* of the Natural History Museum at Stockholm. And indeed all of these fossils have proven so unexpectedly characteristic that I deem it of use to give here a brief account from my notes as intended mainly for a taxonomic study of the American Fossil Cycads, now in course of preparation for the Carnegie Institution of Washington.

(1) *Cycadeoidea etrusca.*—The features of this segment of a columnar trunk are already familiar through the descriptions and figures of Capellini and Solms. The specimen is of great beauty, the texture dense, the color quite dark, the general outer appearance somewhat intermediate to the Wyoming *Cycadella* and *Cycadeoidea nigra* from Colorado. Numerous young fruits are present, and through the great courtesy of Senator Capellini I was enabled to study thin sections prepared from one of these some years since. Especially the thin section of the young axis figured by Solms is of even greater interest than I had anticipated; for although the tissues of the sporophyll rachides are mostly broken down, the entire and uncompressed outlines of both the sporangia and the walls of the synangia of the usual *Cycadeoidea* (Marattiaceoid) form seen in the American specimens, are certainly often present. Only the individual cells of the outer or palisade layer of the synangia do not seem to be conserved. An outline of a synangium cut in the longitudinal transverse direction is quite distinct; while an obliquely cut synangium shows three adjacent sporangia filled full of collapsed (or desiccated) pollen grains, the enclosing locular walls being very perfectly conserved. The pollen is seemingly mature, and the synangia are even larger than in *C. dacotensis*, although the fruits are of a much smaller size.

The small central ovulate cone, no more than a centimeter long, is very perfectly outlined, the short stalked and minute ovules distinct. In size and general structure these fruits may eventually prove more like those of *Cycadella* than *C. dacotensis*. From the rather small size of the staminate fronds, it seems that these were more reduced than in *C. dacotensis* or *C. ingens;* but whether they were bipinnate, pinnate, or simply consisted in a single blade, bearing synangia laterally inserted, much as the megaspores are borne by the carpophylls of *Cycas*, remains impossible to say. These small fructifications may at least prove to have a rather more reduced form than those of *Cycadeoidea dacotensis*. Transverse sections of *C. etrusca* fruits are lacking, but should be made, as they may show the disk features much better than do longitudinal sections. The vegetative structures, however, agree with those of the Maryland cycads very closely throughout,—only the species remaining fairly distinct from *Cycadeoidea marylandica*, if we hypothetically consider the plant on the basis of vegetative features alone.

I may add that I also had the pleasure of visiting the wonderfully interesting and picturesque Etruscan town site and necropolis where *C. etrusca* was found. These ancient ruins are situated in the grounds of Count Aria in the picturesque valley of the Reno, 20 miles west of Bologna in the foot-hills of the Apennines. After seeing how the stream is there cutting away the last remnants of what was once a regularly laid out town of considerable size, I am still more impressed with the likelihood of the suggestion I have once made that not a few of the fossil cycad trunks were gathered into towns or cities now in ruins or long since destroyed. That *C. etrusca* is at least as ancient as the old River Reno Etruscan village and necropolis of 4,000 years ago is certain; for it bears near its base, as noted by Capellini, an elliptical polished-out depression of considerable size, due to use as a smoothing or a sharpening stone, which may just as well have been of neolithic as later date. At any rate, the great perfection of the specimen indicates that in all probability it did not occur alone; and perchance the occurrence of associated silicified conifers may yet aid in giving some clue to the original locality, which, if found, would doubtless yield yet other cycad specimens of rare perfection and interest. The same remark applies even more pointedly to the great Dresden trunk, concerning the macroscopic features of which I proceed to give additional facts.

(2) *Cycadeoidea Reichenbachiana.*—This notable type, now in the paleontological collections of the Zwinger Museum at Dresden, was found not far from Lednice near Cracow about 1753. It consists in the basal segment of an immense silicified cycad trunk a full half-meter in diameter and of noticeably but not markedly compressed unbranched columnar form. In life it may have been more than a meter high, as the segment recovered is over a half-meter in height and without tapering.

The leaf bases are a little smaller than those of *C. Jenneyana* and *C. ingens*, and of much the same size as those of *C. gigantea* of Seward from the Isle of Portland, and the very similar *C. excelsa* of Ward from the Black Hills. The trunk has just emerged from its pulcherrima stage of growth, that pre-fructification period well illustrated by *Cycadeoidea megalophylla* Buckland; and, as indicated by large groups of bracts marking the individual axes of fructification, and especially by the manner in which the bracts close in compactly at the center of the bract groups, many young fruits are present. Of these fruits three, and perhaps more, are very clearly in the bisporangiate or nondehiscent-disk or flower-bud stage so well exhibited by our American specimens. Moreover, in one of these three buds the disk structure is strikingly clear. In it the curved middle portions of the unexpanded and presumably bipinnate microsporophylls have been so eroded away as to clearly reveal in transverse section sixteen circularly disposed microsporophyll rachides. And one may plainly see that these sections of the rachides of triangular outline abut and enclose an inner mass of closely packed and wonderfully conserved synangia of large size, rising above and concealing a central ovulate cone. The individual synangia are evidently attached to the rachides in normal position. This is the first time that the presence of such silicified flowers has been definitely confirmed in European trunks.*

In size and general structure the bisporangiate strobilus of *C. Reichenbachiana* with its 16 microsporophylls closely agrees with that of *C. dacotensis* with 17 or 18, with perhaps a decidedly interesting difference in the apparently larger size of the synangia. The structure of the synangia is unquestionably preserved; indeed, although familiar with quite 1,000 trunks, I know of no other fossil cycad so beautifully and magnificently silicified as *C. Reichenbachiana*. It is even probable that the entire structure of the staminate fronds as well as the synangia is preserved in the greatest perfection, whence it is of very distinct interest to paleobotanists that, as I was informed at Dresden, Solms-Laubach is soon to carry out an exhaustive histologic study of this famous fossil cycad.

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* I am unable to reconcile the features of *C. Reichenbachiana* with the drawing of the "*Bruchstück*" given by Goeppert on Plate IX of the Jubiläums Denkschrift, published in 1853. In fact not only this, but all the accompanying figures are of that uncertain value so characteristic of most illustrations of fossils previous to the extended use of photography,—and that they are quite inexact has already been observed by Professor Ward.

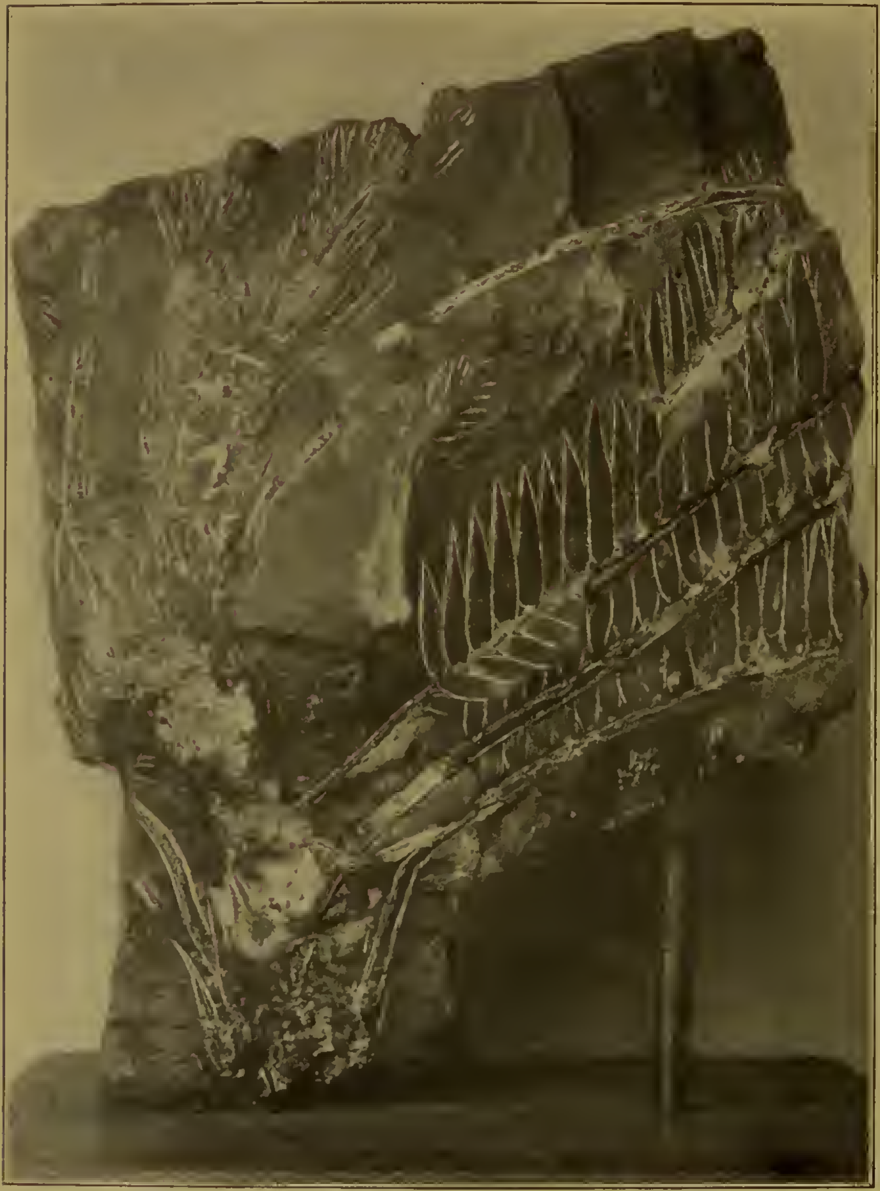
With the Dresden cycad before me it seemed that the large *Williamsonia*-like fruit nearly 5 centimeters in diameter and so prominent in Goeppert's Plate IX must pertain to an accompanying fragment, or even to another specimen; but as the text of the Denkschrift gives no clue to any such, I must conclude that during or since the time of Goeppert the fruit illustrated was partly or wholly broken away.

Goeppert supposed these axes to be vegetative and like the lateral buds of old *Cycas* stems; but Professor Ward notes that they are fruits and thought seeds must be found in some. In which he is wholly correct, since nearly all must bear young ovulate cones hidden beneath the thick husk of enclosing bracts, which is in the great majority of cases all that can be seen at the surface of the trunk. Fully fifty young floral axes are present.

As we have seen, *Cycadeoidea Reichenbachiana* adds another member to the long series of trunks extending from columnar types which have mostly, though not always, large leaf bases, to the great branching types from America, which are mostly characterized by leaf bases of moderate or small size. Moreover, while *C. Reichenbachiana* is a columnar form, its flower bud agrees closely with that of the branching cycads of the Black Hills, especially *C. dacotensis.* It therefore remains to add that in the light of these new facts concerning long known European cycads, the family name Cycadeoideæ used by Robert Brown (1828) certainly includes all the forms which English writers on fossil plants have much later mistakenly placed in their so-called Bennettiteæ. Similarly, the proposal that *Cycadeoidea* (1827) shall be the generic term used for stems without recognizable fructifications cannot be accepted for the simple reason that not only are the Buckland specimens vegetatively like the other trunks from Europe as well as the American forms, but, to go no further than the evidence afforded by the original descriptions, the tangential section figured by Buckland eighty years ago clearly shows a large and characteristic peduncular bundle. As to the genus *Bennettites* (1867), this can at the very most include two or three species so far as known, the great majority of the species of Cycadeoideæ falling within other genera. And so far as truly problematic trunks of unknown fructification and really doubtful vegetative characters are concerned, it only needs to be remarked that there is already at hand for their reception a plethora of such names as *Yatesia*, *Withamia*, *Becklesia*, *Fittonia*, *Clathraria*, *Cylindropodium*, and *Bolbopodium.* It would certainly be as illogical to insist that we require to relegate to a minor position a correctly used generic name for the sake of a handy nomenclature for cycad trunks without distinct or distinctly conserved fructifications, as it would be to say that we can never learn the fructification of a fossil whose vegetative features are the first to be discovered, or are, as in this case, the *first to be understood.* Clearly, therefore, those who would further use the family name Bennittiteæ, or the generic name *Bennittites*, in other than a wholly restricted sense, must err in both these respects.

Let us now turn our attention briefly to two of the cycadeoid imprints and casts, which are quite as famous as the silicified trunks just discussed, and which supplement and add to our knowledge of the Cycadeoideæ in such a remarkable manner,—namely *Williamsonia* and *Anomozamites.*

(3) *Williamsonia gigas* (Paris Museum specimen with leaves attached).*—This is by far the most important specimen of the James Yates collection of Williamsonias from the Juras-



Williamsonia gigas (Echantillon No. 2399*a* *Jardin des Plantes*, Paris, Collection Yates, 1827). Terrainoölithique inférieure, Scarborough et Whitby. The fronds to the right are of an old series; above these are large scale leaves somewhat interiorly to which rise the petioles evidently of a younger series of full grown fronds,—the main axis ending in a forked bract enveloped peduncle and possibly being capable of further growth after the production of its flowers, just as is the *Cycas* axis. ($\frac{2}{5}$ natural size.)

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* The present drawing of this remarkable cycad is superposed on a photograph furnished to me through the great liberality of the officials at the *Jardin des Plantes*.

sic sandstones of Hawkser and Runswick cliffs, secured by Brongniart. Imperfectly figured by Saporta in the Plantes Jurassiques, vol. ii, it was casually mentioned by Solms-Laubach in his Fossil Botany as the only cycadean stem known to him with leaves attached, and later still by Seward, who observed the presence of the terminal and typical *Williamsonia* peduncle. Yet we remain without an adequate description; for, although a silicified *Ptilophyllum* stem with frond bases bearing a few pinnules has been reported from India, and though many of the silicified stems from the Black Hills bear entire crowns of young fronds, here is the only cycadophyte known in all the world's museums with quite complete mature fronds plainly attached to the parent stem. Moreover, the present plant differs markedly from the above forms in its stem characters only, and is a fundamentally important connecting link between *Cycas* and those *Cycadeoidean* types with much reduced laterally-borne fructifications. It is, too, a fossil of great beauty;—conserved as a semi-cast, or combination of cast and imprint in a block of grayish white sandstone (Lower sandstone of Phillips), traces of the original carbon add very markedly to the clearness of the outlines of the stem, fronds, bracts, and peduncle. All of the features are exposed by a single fortunate split of the matrix which reveals the connection of the stem and petioles of at least three of the fronds, one above the other; while various other fronds traversing the matrix make it clear that all of the fronds of a sparse crown are present and, in most cases, connected. That is, an entire plant with mature fronds and large fruits, as indicated by the prolongation of the stem as a peduncle, is surprisingly well shown. In life the foliar crown was of the same size as one of our Florida Zamias, with fronds a little less than two feet in length; but the stem, the basal portion of which is broken away, was slenderer—less than five centimeters in diameter, armor and all, and may have been long. Easily the most striking feature is the continuation of the main axis with but slight constriction and no evidence of lateral budding, as a bract-covered peduncle. This rises to a height of some ten centimeters above the leafy crown and then forks just where cut off by a transverse fracture studded by small barnacles. As thus plainly indicated, the fossil came from a point on the Hawkser or Runswick cliffs between high and low tide, and may even have been found *in situ*, rather than as talus material, if the fruits *were turned toward the cliff-face.* The barnacle-studded fracture is but little water-worn, and the forked peduncle appears to be broken off just at the base of two large fruits, or, as is quite as likely, a single fruit and the new phytaxis.

In short, it seems highly probable that had the importance of the specimen been at once realized when collected some eighty years ago, it would have been possible to find, either associated with it or remaining behind in the cliff, the block containing the entire summit. Indeed, in looking through the other James Yates specimens of the *Jardin des Plantes*, I could not help hoping every moment to find the barnacle-covered end of a block matching the broken end of that of the main stem, and containing the missing flowers. And, although I failed to observe any such with certainty, there still remains a suspicion that the iron mountings of the specimen prevented my search from being wholly conclusive, and that some one of the beautiful accompanying series of *Williamsonia* flower buds was really borne on the forked peduncle. At least, this not proving so, it seems to me that if there exists at Cambridge or elsewhere in England a slab bearing a pair of *Williamsonia* fructifications, with the peduncles broken away at their bases and ending on a transverse fracture of the matrix, dotted over with barnacles, or similarly, a fruit and a bud lying side by side and oriented alike, it ought in the interests of paleontology to be carried to Paris and compared with the *Jardin des Plantes* specimen.

I do not think I am deceived in stating that the peduncle forks; although whether it is at first a true monopode or integral prolongation of the stem instead of a lateral branch, is more uncertain. As already suggested, however, it appears to rise monopodially, and to thus exhibit precisely that form of fruiting hypothetically intermediate between *Cycas* and the reduced laterally-borne cones and flowers of *Cycadeoidea*. If, as must be borne in mind, the peduncular prolongation of the stem bore one flower and a new phytaxis, instead of two flowers, we of course have here repeated in the Jura very nearly the same fruit-bearing and branching habit as in that remarkable related form of the Triassic, *Anomozamites*. In either case, however, the condition observed forms, *a fortiori*, a connecting link of profound interest between the Cycadeoideæ and the Cycadaceæ. For, restating the case: in the female *Cycas*, strobilar elongation of the stem following a bract series or scale-leaf series, is integral—monopodial; while here there appears to be a partially restricted elongation of the stem which likewise follows a bract series and is presumably capable of producing a fruit-bearing branch, and also of subsequent growth as a new phytaxis. There is little suggestion of a fruit-bearing sympode or flowering stalk.

Much more,—if we begin to think out hypothetically related forms with much branched yet slenderer stems, netted veined *(Dictyozamites)* leaves and primitively plastic multiovulate sporophylls, we soon arrive at a remote type of Proangiospermous plant near to or actually a true *pre*-Angiosperm, or Hemiangiosperm, as named by Newell-Arber from what is justly my own point of view. But this line of inquiry is more appropriate to another chapter. Meantime, it seems extraordinary that the fossil before us has received such scant notice in texts, and that just as if it had never existed, the correctness of Williamson's restoration was so long called in question despite the added authority of Brongniart.

(4) *Anomozamites minor* Nathorst.—The accurate descriptions of the original types given thirty years since by Nathorst, and more recently in his contribution on *Einige Mosozoischen Cycadophyten*, leave little to add here, except by way of emphasis of the great botanical importance of this oldest of known cycadeoids. These specimens, still unfortunately few in number, are not only among the most priceless in the superb collections of fossil plants in the Natural History Museum at Stockholm, but deserve a foremost position amongst all fossil cycadophytes.

In my American Fossil Cycads I have in unmistakable terms urged the great importance of *Anomozamites*, which by reason of its slender much branched stem, its small blade-like leaves, and its small fruits of *Williamsonia* type (apparently with 18 microsporophylls), is certainly more suggestive of relationships to primitive Angiosperms, that is to the Magnoliaceæ as determined independently by both Hallier and myself, than is any other of the better known cycadeoids. Indeed the only possible contestant for this position of primary importance which can so far be suggested is *Dictyozamites*. Because of its netted veined leaves, we may well suspect that this cycadophyte, now known to be one of the cosmopolitan forms, may show yet closer approximations to Dicotyls—once we are fortunate enough to find its fruits. For it need surprise no one if these should for instance exhibit that more primitive bisporangiate combination of the Cycas-like, or *multiovulate carpophyll*, with *reduced microsporophylls*, or stamens, which one may safely predict will be yet discovered in considerable variety amongst the cycadeoids.*

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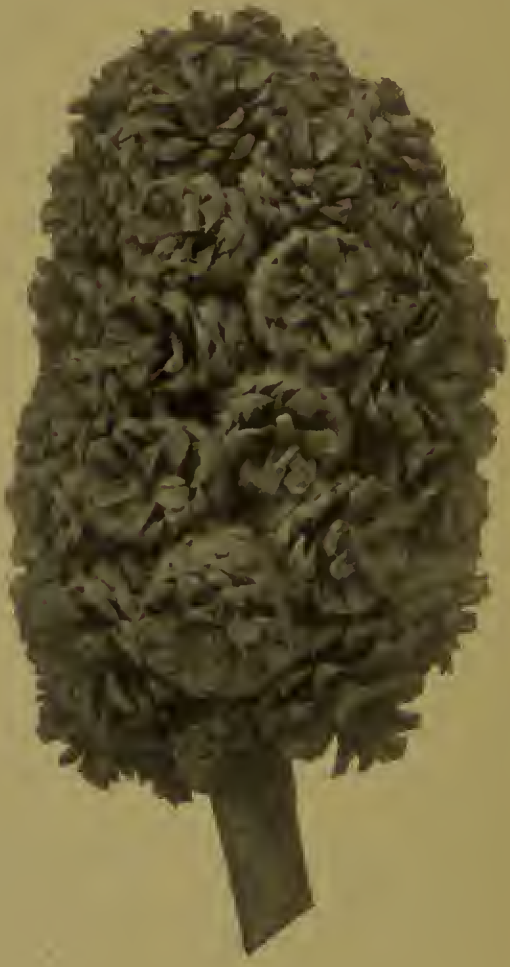
* With the present additions, the known species of Cycadeoidean amphisporangiate flowers now number quite a dozen distributed in five more or less cosmopolitan genera, ranging through the entire Mesozoic, and antedating the angiosperms in the most suggestive manner as follows :

1.	*Anomozamites minor ;*	Microsporophylls	17 or 18.	—Trias.
2.	*Cycadella wyomingensis ;*	"	13	—U. Jura.
3.	*Cycadeoidea dacotensis ;*	"	18	—Wealden.
4.	" *etrusca ;*	"	—	—L. Cretaceous (?).
5.	" *ingens ;*	"	13	—Wealden.
6.	" *Jenneyana ;*	"	10 or 11.	— "
7.	" *Paynei ;*	"	——	— "
8.	" *Reichenbachiana ;*	"	16	— "
9.	" *Superba ;*	"	——	— "
10.	" (Species) ;	"	——	— "
11.	*Cycadocephalus Sewardi ;*	"	17 or 18.	—Trias.
12.	*Williamsonia gigas ;*	"	15 or 20.	—Jura.

Art. X.—*Accelerated Cone Growth in Pinus*; by G. R. Wieland.

The rare but suggestive instance of multiseriate production of ovulate cones in *Pinus rigida*, illustrated in the accompanying figure, has been recently brought to my notice by one of my colleagues.* This conspicuous group of cones appears to have been derived from some New England source many years ago, having been found with a series of geological specimens collected or left in the Peabody Museum by Professor Benjamin Silliman and probably not examined since his day.



As appears in the figure, the individual cones, of which there are fifty-three in all, are nearly all of normal or approximately normal development and so regularly crowded together on their common axis as to simulate, taken *en masse*, some such single huge cone as that of *Pinus Coulteri*. It is clear enough, however, that the entire growth of cones is not in any complete sense an abnormality; for each cone must appear normally in the axil of a bract, just as do the several up to half a dozen cones in the usual ovulate clusters [or whorls], and exactly as in the case of the far more numerous cones of the corresponding staminate groups.

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* At the time this note was first written it seemed to me that its interest was somewhat lessened by the fact that after diligent search and inquiry I failed to learn of additional examples of clustered *Pinus* cones. Since then, however, I have seen three large and even finer clusters in the collections of the *Jardin des Plantes*, Paris. No label accompanied these specimens, which represent at least two more species of *Pinus* exhibiting accelerated cone growth.

Also, similarly to both ovulate and staminate cone-bearing axes, as well as to occasional single ovulate cones, the main or vegetative axis was prolonged; although, having been broken away, this feature does not appear in the figure. The present very unusual or even unique group of cones has therefore been produced in the simplest possible manner, namely, by increase in number and crowding to the extent of about a dozen of the ordinary ovulate clusters.

Moreover, it is from its very simplicity of origin that this fine example of accelerated proliferation appears to me to derive an instructive interest; for of late there have been accumulating various significant facts pointing toward a derivation of all existing spermaphytes from primitive ferns by way of pteridospermous types. Indeed, it now appears quite probable that the production of ferns may well have been Nature's fundamentally greatest achievement in vegetal evolution, and that following this great step, perhaps thoroughly accomplished in Silurian time, advance in reproductive structures was largely along lines of lesser resistance rather than by sheer forward movement. That is, broadly as well as theoretically speaking, the hiatus between monœcious fern prothalli and the seeds of pteridosperms and finally of gymnosperms and angiosperms; or, more definitely still, the hiatus between asexual fertile fern fronds, and the microsporophyll and carpellary leaf, the stamen and carpel, as seen in their thousand-and-one combinations in strobili flowers and inflorescences, was bridged not so much by the outright evolution of new organs as by more roundabout methods. Such, for instance, are, following the development of either generalized types or organs, extreme reductions, the secondary requisition of organs not originally evolved for the specific purpose or use finally assumed, and especially rearrangements or regroupings of fertile axes with sporophyll changes sequent to accelerated branching.

Now, if such conceptions of the descent of the higher types of existing plants from the ferns can in any sense approximate the truth, then the question as to the extent to which sporophyll reduction entered into the evolution of primitive types of cones from a main terminal strobilus like that of *Cycas* at once arises. And directly corollary to this inquiry there immediately comes up for discussion the further possibility of accelerated branching with marked increase in number of partially reduced fertile axes. Such, whenever assuming a more or less compacted order constituting in reality primitive types of inflorescences, would, if once coming to appear habitually, readily undergo still other subsequent mutations of form. For example, how else than by some such course of evolution as that here briefly suggested, has the male cone (inflorescence) of *Welwitschia* arisen? It is certainly thinkable that an initial period of sporophyll reduction and accelerated branching in some ancient pteridospermous ancestor characterized by large bractlike leaves, could result in a *growth* of fertile axes in compacted groups more or less analogous to that before us, and that a secondary course of reductions may then have intervened and produced the condition we now see. In other words, we imagine that in the diœcious *Welwitschia* single flowers originally derived from fertile terminal buds of vegetative form have, following increase in number, undergone extreme reduction and modification into "cones," the ovulate forms of which have lost their microsporophylls. Furthermore, if each cone of a group more essentially like that illustrated were to be reduced so as to produce but a single seed, another interesting type of conoid inflorescence would be outlined; though such a form could scarcely be as capable of wide variation as a still more primitive series of spirally inserted multiovulate sporophylls.*

It is thus of decided interest to have clearly brought home to us by such a simple form of accelerated branching as that of *Pinus*, the very interesting fact that by reason of new *emplacements* wholly new series of modifications in organs of reproduction may take place. These hypothetical *en masse* changes following the earlier evolutionary stages of primitive sporophylls pointedly suggest how the endless variety of angiospermous fructifications can have arisen from plant types not very remote from but still more primitive than the Cycadeoideæ; while contrariwise in races with few ovules to the carpel and little phytologic plasticity like the conifers, such realignments and modifications have in post-Triassic time seldom appeared or become habitual with a resultant displacement of the plastic stock by its better equipped descendants.

[April 25, 1906.]

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* The gymnosperm cone itself, both simple and compound, is throughout derived by branching from a primitive main axis. The sporophylls of both sexes are of course all derivatives of pteridospermous fronds; and dorsal, ventral, or lateral insertion of sporangia is of purely secondary import, since resulting in the simplest possible manner during the process of extreme reduction in which all circinnate prefloration was displaced by obscured conduplicate, or direct forms, with formation of various types of appression faces. Finally, in the Coniferales, sclerotization into regularly interlocking spirally inserted prismoids resulted in the nearly aplastic bracts and carpels, which have changed but little since the Jura. Appositely it is hypothesized that a diminution in the number of primitive sporophylls, followed only secondarily by spore decrease in number, would conserve the requirements of carpellary plasticity.